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TRANSMISSION OF GENERIC DIGITAL MESSAGES THROUGH A MICROPROCESSOR MONITORING CIRCUIT

The present invention relates to the testing of microprocessors. It more specifically relates to a method and device of digital data transmission between a test circuit integrated in a microprocessor chip and an analysis tool.

Fig. 1 schematically shows an integrated circuit 10 comprising a microprocessor (µP) 12, an internal memory (MEM) 14, and input/output terminals (I/O) 16. Microprocessor 12 is intended to execute a program or a software stored in memory 14. Under control of the program, microprocessor 12 can process data provided by input/output terminals 16 or stored in memory 14 and provide data through input/output terminals 16.

To check the proper operation of the microprocessor, a supervision circuit 18 (TEST) is generally integrated to integrated circuit 10. Supervision circuit 18 is capable of reading specific data provided by microprocessor 12 on execution of a program, and of possibly processing the read data. Supervision terminals 22 connect supervision circuit 18 to an analysis tool 24. Analysis tool 24 may process the received signals, for example, according to commands provided by a user, and ensure a detailed analysis of the operation of microprocessor 12. In particular, analysis tool 24 may determine the program instruction sequence really executed by microprocessor 12.

The number of supervision terminals 22 for a conventional supervision circuit 18 may be on the same order of magnitude as the number of input/output terminals 16 of microprocessor 12, for example, from 200 to 400. Test terminals 22 as well as the connections of supervision circuit 18 take up a significant silicon surface area, which causes an unwanted increase in the circuit cost. For this reason, a first version of integrated circuit 10 comprising supervision circuit 18 and supervision terminals 22 is produced in small quantities to check out microprocessor 12. After this checking out, a version of integrated circuit 10 rid of supervision circuit 18 and of supervision terminals 22 is sold. This implies the forming of two versions of the integrated circuit, which requires a significant

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amount of work and is relatively expensive. Further, the final chip is not identical to the tested chip.

To overcome the above-mentioned disadvantages, it is desired to form a supervision circuit 18 which takes up a reduced surface area and only requires a reduced number of test terminals 22, which decreases the selfcost of supervision circuit 18. Supervision circuit 18 can then be left on the finally sold integrated circuit 10.

It is thus desired to decrease the number of signals provided by supervision circuit 18. For this purpose, certain logic operations are directly performed at the level of supervision circuit 18 on the data measured at the level of microprocessor 12 to only transmit messages having an important information content.

Thus, standard IEEE-ISTO-5001 in preparation provides in its 1999 version, accessible, for example, on website www.ieee-isto.org/Nexus5001, a specific message exchange protocol between a supervision circuit 18 and an analysis tool 24 for a supervision circuit 18 requiring but a reduced number of test terminals 22.

Standard IEEE-ISTO-5001 provides several standardized messages, called public messages, the features of which are set once and for all and cannot be modified by the users of chip 10. Among the public messages, program tracing messages and data messages are especially distinguished. Program tracing messages provide information relative to the order of execution of the program by microprocessor 12. It may for example be a message indicating that a jump has occurred in the program executed by microprocessor 12. Data messages gather the other public messages that can be transmitted by supervision circuit 18 and especially provide information relative the data processed by microprocessor 12. It may for example be a message indicating that a data read or write operation in an area of memory 14 has been performed by microprocessor 12.

Each public message is formed of a succession of bits distributed in several juxtaposed groups comprising a header group and secondary groups,

each group coding specific data. The header group corresponds to a message type identifier. It is formed of a fixed number of bits identical for all public messages. The number of secondary groups of a given public message and the size of each of them are set by the value of the message identifier. As an example, in the case of a jump message, the secondary groups may correspond to data representative of the address of the jump destination instruction and to the number of instructions executed by microprocessor 12 since the last transmission of a jump message. In the case of a message indicating a data read or write operation, the secondary groups may correspond to the address of a register of memory 14 where the data are written or read and to the data value.

Based on the public messages, in particular, based on the program tracing messages, analysis tool 24 restores the instruction sequence executed by microprocessor 12. The restored instruction sequence can then be compared with an instruction sequence theoretically executed by microprocessor 12 to determine malfunctions of microprocessor 12.

Standard IEEE-ISTO-5001 also provides the possibility for the users to define specific messages that can be transmitted by supervision circuit 18 in addition to the public messages. A specific message is intended to be used when none of the public messages provided by the standard enables performing a function desired by the user. A specific message comprises, like a public message, a first group of header bits corresponding to an identifier of the specific message. The arrangement of the other bits of the specific message follows no particular rule and may considerably vary from one user to another. Further, analysis tool 24 connected to supervision circuit 18 must comprise processing means adapted to the processing of the specific messages.

In practice, each user wants supervision circuit 18 to transmit specific information which especially depend on the architecture which has been defined for microprocessor 12. The user then tends to privilege the use of specific messages over public messages to exactly transmit the wanted information. This decreases the advantage of standard IEEE-ISTO-5001 since, in practice, most of the messages transmitted by supervision circuit 18 are not public messages.

In this case, it is very difficult to provide analysis tools 24 that can be used in interchangeable manner by supervision circuits 18 designed by different users and that implement different specific messages.

The present invention provides transmission of adaptable messages, the provision of which complies with determined rules to be able to easily implement new functions without requiring definition of specific messages and to enable use of more standardized analysis tools.

An advantage of the present invention is that it uses messages having a structure compatible with that of the public messages already provided by standard IEEE-ISTO-5001, which favors the above-mentioned standardization.

To achieve this object, the present invention provides a method for transmitting digital messages through output terminals of a microprocessor supervision circuit of a determined type from among several supervision circuit types integrated to a microprocessor, each message comprising a message identifier and being formed of several groups of successive juxtaposed bits, the bit groups being divided in one or several segments each comprising a determined number of bits, the method consisting of successively transmitting segments associated with the successive juxtaposed bit groups comprising a first bit group corresponding to the identifier and comprising a fixed number of bits whatever the supervision circuit type; second bit groups, at least one of the second groups comprising a fixed number of bits depending on the identifier and on the type of supervision circuit, the number of the other second groups depending on the identifier and being independent from the supervision circuit type; a third bit group comprising a number of bits greater than one and depending on the message to be transmitted; and fourth bit groups each comprising a number of bits greater than one and depending on the message to be transmitted, the number of fourth groups depending on the identifier, on the supervision circuit type, and on the message to be transmitted.

According to an embodiment of the present invention, said at least one of the second groups is juxtaposed to the first group.

According to an embodiment of the present invention, said other second groups have a number of bits which depends on the identifier and which is independent from the type of supervision circuit.

According to an embodiment of the present invention, said other second groups have a number of bits greater than one which depends on the message to be transmitted.

The present invention also provides a device of digital message transmission through output terminals of a supervision circuit, of a determined type from among several supervision circuit types, integrated to a microprocessor, each message comprising a message identifier, said device comprising means for providing groups of successive juxtaposed bits forming the message, means for dividing the bit groups in one or several segments each comprising a determined number of bits and means for successively transmitting said segments, the bit group provision means being capable of successively providing a first bit group corresponding to the identifier and comprising a fixed number of bits identical whatever the supervision circuit type, second bit groups, at least one of said second groups comprising a fixed number of bits depending on the identifier and on the type of supervision circuit, the number of the other second groups depending on the identifier and being independent from the supervision circuit type, a third bit group comprising a number of bits greater than one and depending on the message to be transmitted, and fourth bit groups each comprising a number of bits greater than one and depending on the message to be transmitted, the number of fourth groups depending on the identifier and on the determined supervision circuit type.

The foregoing object, features, and advantages of the present invention, as well as others, will be discussed in detail in the following non-limiting description of specific embodiments in connection with the accompanying drawings, among which:

Fig. 1, previously described, very schematically shows the architecture of a chip integrating a microprocessor and a supervision circuit; and

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Fig. 2 shows an example of a message provided by the supervision circuit to an analysis tool according to the present invention.

The present invention provides modifying the structure of the public messages already provided by standard IEEE-ISTO-5001 to enable transmission of messages adapted to the requirements of different customers.

Fig. 2 shows a message according to the present invention. The bits are shown from the least significant bit to the left of the drawing to the most significant bit to the right of the drawing. The message bits are transmitted by supervision circuit 18 in this order. The message comprises a first group of bits TCODE corresponding to a fixed number of bits identical for all messages. The first bit group is equal to an identifier of the message. Thus, in addition to the identifiers also provided by standard IEEE-ISTO-5001, the identifier group may take different other values according to the customers' requirements. As an example, standard IEEE-ISTO-5001 provides an identifier group set to six bits. According to the present invention, the number of bits of the identifier group may be increased according to the number of messages to be provided to comply with the customers' requirements.

Identifier group TCODE is juxtaposed to a fixed customer group CUSTOM. The number of bits forming fixed customer group CUSTOM is set by the customer for each possible identifier value. Fixed customer group CUSTOM may possibly comprise no bit. Fixed customer group CUSTOM may represent any type of data that the customer wants to transmit to analysis tool 24. It may be the concatenation of different values or of data resulting from a processing performed by supervision circuit 18.

Fixed customer group CUSTOM is followed by several juxtaposed mandatory groups MAND_1 to MAND_N. The number of mandatory groups, the number of bits of each mandatory group, and the nature of the data contained in each mandatory group are determined once and for all for each identifier value. The last mandatory group MAND_N of a message according to the present invention necessarily comprises a variable number of bits, where the other mandatory groups can comprise a fixed number greater than one or a variable

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number of bits. A group having a variable number of bits is formed of at least one bit (possibly equal to 0).

The last mandatory group MAND_N is followed by one or several optional juxtaposed customer groups CUST_1 to CUST_N each comprising a variable number of bits. The number of optional customer groups CUST_1 to CUST_N is not defined a priori and may vary for a same identifier and for a same customer according to operating conditions of microprocessor 12.

The provided message structure according to the present invention advantageously uses the data transmission protocol between supervision circuit 18 and analysis tool 24 provided by standard IEEE-ISTO-5001.

According to such a protocol, the bits of successive groups each comprising a fixed number of bits are concatenated to form a single packet having a fixed number of bits. Similarly, the bits of a group having a fixed number of bits and the bits of a group having a variable number of bits which is juxtaposed and follows the group having a fixed number of bits may also be concatenated to form a single packet having a variable number of bits. The packets thus formed are divided into segments of n bits, where n for example ranges between 4 and 16, each segment being intended to be transmitted over an n-bit bus. When the number of bits of a packet is smaller than n, all the bits are copied in a segment and the unused most significant bits of the segment receive a predetermined value, for example, 0. When the number of bits of a packet is greater than n, the n least significant bits of the packet are copied bit to bit in a first segment, after which the next n least significant bits of the packet are copied bit to bit into a second segment, and so on until each bit of the packet has been copied. The unused most significant bits of the last segment thus formed receive a predetermined value, for example, 0. The segments are transmitted in a row over the n-bit bus at the rate of a clock signal specific to supervision circuit 18. To enable reconstructing the data packets from the segments, it is provided to transmit with each segment on the additional test terminals a transmission code which enables the analysis tool to identify data contained in the segment.

Standard IEEE-ISTO-5001 provides transmission codes to identify:

a message start segment;

an intermediary segment of a packet having a fixed or variable number of bits;

a packet end segment having a variable number of bits, when such a packet is followed by another packet of the same message;

a message end segment; and

an empty segment corresponding to an idle period between messages.

The position of optional customer groups CUST_1 to CUST_N in the transmitted message advantageously uses the previously-described protocol since analysis tool 24 needs not previously know the number of optional user groups CUST_1 to CUST_N present in the message. Indeed, optional customer groups CUST_1 to CUST_N are groups having a variable number of bits placed at the end of the message. When optional customer groups are present, a specific identification code indicating an end segment of an optional customer group is thus provided by supervision circuit 18 between each optional group on transmission of optional customer groups CUST_1 to CUST_N. This enables analysis tool 24 to count the optional customer groups on reception of the message.

The present invention further enables modifying the composition of the messages to be transmitted to adapt them to the customers' requirements while enabling transmission of the public messages already provided by standard IEEE-ISTO-5001. Since the position of the groups in a message is set for all the messages according to the present invention that can be transmitted by supervision circuit 18 to analysis tool 24, it is possible to standardize as much as possible the calculation algorithms of the analysis tool for the processing of the received messages. A configuration file is transmitted to analysis tool 24 so that it is acquainted of the messages that can be transmitted by supervision circuit 18 and in particular that it is acquainted for each message of the number of bits (possibly equal to zero) forming fixed customer group CUSTOM. On reception of a message by analysis tool 24, analysis tool 24 thus knows the position of fixed

customer groups CUSTOM and can thus analyze all the data present in this group. Optional customer groups CUST_1 to CUST_N being clearly identified by analysis tool 24, they can be ignored by an analysis tool 24 which would not be capable of processing them.

The nature of the data contained in fixed customer group CUSTOM may be standardized. The customers are thus offered a selection of possible configurations of the fixed customer group to standardize analysis tool 24 more. Such a group may in particular contain data which are used by analysis tool 24 for the processing of optional customer groups CUST_1 to CUST_N.

Of course, the present invention is likely to have various alterations, modifications, and improvements which will readily occur to those skilled in the art. In particular, the possibility for the users to define specific messages in addition to the messages according to the present invention may be maintained.